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COMPLETE SPECIFICATION

DRAWINGS ATTACHED

Gas Treatment of a Moving Artificial Multi-Filament Thread

We, N. V. ONDERZOEKINGSINSTITUUT RESEARCH, a Company organized and existing under the Laws of the Kingdom of the Netherlands, of 76, Velperweg, Arnhem, Holland, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The invention relates to a method for treating a moving multi-filament thread with a stream of gas so that the filaments of which the thread is composed are intertwined.

Artificial multi-filament threads have little or no twist and in consequence, it is extremely difficult to subject them to textile treatments, such as weaving and knitting since the structure of these threads is too loose. In order to prevent a loose structure, artificial multi-filament threads are usually twisted, and if necessary, the twisted threads are also sized in order to impart greater coherence to the filament from which the thread is composed.

Since twisting is a time consuming and costly operation, many attempts have been made to find other methods by which the structure of artificial multi-filament threads having little or no twist can be condensed. It is generally known that the loose structure of artificial multi-filament threads may be condensed by passing the threads through an enclosed space in which a gas jet is directed onto the thread, the thread being withdrawn from the enclosed space at a rate which is practically the same as the rate at which it was supplied to said space.

As a result of the jet blowing against the slightly tensioned thread, the filaments of which the thread is composed are intertwined. The resulting thread withdrawn from the enclosed space has practically the same denier as the original thread, and the filaments are interlaced and have a condensed structure. As the thread is under a slight tension during the treatment, the treated thread has a tense appearance and no loops are apparent on the surface.

For the purpose of this specification, a thread thus treated, will hereinafter be referred to as "tangled yarn".

The tangled yarn thus obtained need not be twisted before being processed either on weaving or on knitting machines, although in some cases it may require sizing.

According to the present invention there is provided a method for treating a moving artificial multi-filament thread having little or no twist with a stream of gas, which method comprises directing at least one primary gas stream having a velocity of at least 200 m/sec. on to a thread running between guides, guiding the gas stream after it has passed the thread, into an enclosed space and subsequently directing the gas stream from the enclosed space on to the thread as a single or multiple secondary gas stream at a point or points remote from that at which the primary gas stream comes into contact with the thread, wherein the primary gas stream issues from a primary gas jet at a gauge pressure within the range 0.5 to 10 atmospheres, and wherein the thread passing the gas streams is under a tension of from 0.03 to 0.3 gm. per denier.

In this way a primary gas stream is utilized two or more times which not only yields a yarn having a more condensed structure, but also provides for more economical use of the gas under pressure.

Having passed the thread, the primary gas stream is diverted and may be directed onto the thread again at some other point. However, the primary gas stream may be split up into two or more gas streams which are

directed onto the thread at different points. The velocity of the secondary gas stream or streams should be such that the filaments of the thread are separated and then intermingled; in this way, thorough tangling of the filaments results.

The gauge pressure of the primary gas jet is within the range 0.5 to 10 atmospheres, although at a gauge pressure of less than 0.5 atmospheres, the filaments can still be separated, very little intermingling is observed to occur. However, if the gas being used is steam, good results are still obtained at a gauge pressure of 0.5 atmospheres. When air is used it is preferred that the gauge pressure should be at least 1.5 atmospheres in order to obtain satisfactory entanglement of the filaments.

It is not practicable to employ gauge pressures above 10 atmospheres since this would not only be costly but would also cause the threads to be blown away. As the filaments should have a uniform entanglement along the length of the yarn, gas pressures of less than 10 atmospheres should be employed. Several primary gas streams may be used, which after passing the thread, may be directed onto the thread at different points as single or multiple secondary gas streams.

Any gas not reacting with or affecting the yarn may be employed, for instance, carbon dioxide, nitrogen, and "dry steam", although air is usually preferred.

The artificial multi-filament threads to be treated should have little or no twist; by 'little twist' is to be understood that the thread does not have more than 40 turns per metre.

The method of the invention may be applied to threads of polyamide, polyester, polyalkenes, polyacrylonitriles, cellulose acetate and regenerated cellulose among others. There is no restriction on the cross-section of the thread filaments which may be circular or of a different shape.

The tension in the thread undergoing treatment must be at least 0.03 gram per denier, since, although the filaments will also entangle at a lower tension, the surface of the resulting threads will have filament loops projecting from them. At a tension of more than 0.3 grams per denier, the filaments are not entangled, and in order to obtain entanglement of the filaments with these tensions, the pressures of the gas would have to be considerably higher, which is not practicable or desirable for the reasons set out above.

The gas streams may be directed onto the thread at any angle, although it is preferred that the primary gas stream is directed onto the thread in a direction perpendicular to it. When this is the case, the secondary gas streams are also preferably directed onto the thread, perpendicular to the thread and in a direction opposite to the direction of flow of the primary gas stream.

The velocity of the secondary gas stream should be such that it separates and subsequently interlaces the filaments. If this is not achieved, then the gas pressure in the enclosed space should be increased thereby increasing the velocity of the second gas stream as it leave the secondary nozzles or jets.

It is frequently found that artificial multifilament threads which are to be treated by the method of the present invention, possess a residual electrostatic charge. This electrostatic charge may be removed from the theread after the treatment in accordance with the present invention by simply wetting the thread, for instance with water containing a wetting agent. In some cases, it may be advantageous to add a sizing agent to the water.

The invention also provides for an apparatus for carrying out the method of the invention, which apparatus comprises a nozzle through which the primary gas stream issues, a chamber provided with an opening opposite the exit of the nozzle, and thread guides so that the line passing through the centres of the thread guides will intersect with the centre line of the nozzle exit, wherein the distance between the nozzle exit and the centre line passing through the thread guides is between 1 and 3 mm, and wherein the chamber is provided with at least one outlet for discharging the gas from the chamber, which outlet debouches towards the thread and at a distance from 0.5 to 2.0 mm. from the centre line passing through the thread guides, but at some distance from the point of intersection of the centre line of the thread guides and the centre line of the nozzle exit.

The bore of the nozzles may be round or oval, but other shapes are also suitable. The cross-sectional area of the nozzle bore may remain constant but it is also possible for the bore to diverge towards the end of the nozzle.

If the nozzle exit of the primary gas jet is positioned at less than 1 mm or more than 3 mm from the centre line of the thread guides, then insufficient interlacing of the thread filaments will result. Similarly if the chamber outlet from which the secondary gas stream issues, is positioned at less than 0.5 mm or at more than 2 mm from the centre line of the thread guides, then satisfactory entanglement of the filaments is not obtained. Furthermore, if the gas issuing from the chamber outlet comes into contact with the thread at the same point as does the primary gas stream, then once again insufficient interlacing of the filaments invariably results.

In a preferred construction of the apparatus of the present invention, the centre line of the nozzle exit is perpendicular to the centre line passing through the thread guides. Even better results are obtained if the centre line of the chamber outlet is perpendicular to the centre line passing through the thread guides and if the direction of the gas stream leaving the nozzle is opposite to the gas stream leaving the chamber outlet.

It is preferred that the inlet of the chamber should be similar to the nozzle exit, the ratio of the cross-sectional area of the chamber inlet, to the cross-sectional area of the nozzle exit having a numerical value within the range 1 to 2 and the chamber outlet should have a diameter which is less than the inlet of the chamber. The outlet of the chamber may be formed by a nozzle.

If it is desired to increase the degree of entanglement of the filaments within the thread, a series of the apparatus described above may be employed, one after the other, for treating a running thread.

Following is a description by way of example and with reference to the accompanying drawings, of several embodiments of the apparatus of the present invention and of methods of carrying the invention into effect. It is to be understood that the invention is not limited to the embodiments and methods to be described.

In the drawings:

Figure 1 is a section through an embodiment of the apparatus of the present invention in which a secondary gas stream is directed at the thread both before and after the incidence of the primary gas stream.

Figure 2 is a section through 2-2 of Figure 1,

Figure 3 is a section through an embodiment of the apparatus in which the secondary gas stream impinges on the thread prior to its passing through the primary gas stream.

Figure 4 is a view in perspective and partly in section of an embodiment of the invention, in which the centre line of the nozzle exit and the centre line of the chamber outlet are in planes which are perpendicular to each other.

In Figures 1 and 2, the thread guides, 3, are positioned so that a moving thread, 4, which passes through these thread guides runs past the exit, 5, of a nozzle, 1, and the inlet, 6, of the chamber, 2, the nozzle exit, 5, is circular and measures 1.2 mm. in diameter, while the inlet, 6, of the chamber, 2, is also circular and measures 1.4 mm. in diameter. The primary gas stream, 7, issues from the nozzle exit, 5, impinges on the thread, 4, and passes into the chamber inlet 6, and on into the chamber, where it is divided into two separate streams 8 and 9. Each of the streams 8 and 9 are further split up into two more streams 8′, 8″ and 9′, 9″, which streams leave the chamber and are directed onto the thread by means of slit-shaped outlets 10′, 10″ and 11′, 11″, (9′, and 11′ are not shown since they do not lie in the plane of the drawing).

The gas streams 8′ 8″, 9′ and 9″, impinge against the thread at different points from the point at which the primary gas stream 7 impinges.

In Figures 3 and 4, the thread guides, 3, serve to guide a thread, 4, past the front of a circular nozzle exit, 5, in nozzle, 1. This nozzle exit measures 1.2 mm. in diameter. Opposite the nozzle exit, 5, there is located a circular chamber inlet, 6, measuring 1.4 mm. in diameter. The chamber is provided with an outlet, 10, in the form of a nozzle, which nozzle has a circular exit of 1.2 mm. diameter.

The gas stream, 7, issuing from the exit, 5, of nozzle, 1, flows past the thread, 4, into the chamber, 2, and leaves by the outlet, 10, which guides the gas stream onto the thread, 4.

In the following examples, the interlaced density, hereinafter referred to as the "coherency factor", of the filaments is determined as follows:—

A thread of at least 60 cm. long is suspended by means of a clamp in front of a vertical scale graduated in centimetres. To the lower end of the thread is attached a clip, the weight of which should be approximately numerically equal to 1/5 the denier of the thread, and in any case should not exceed 100 gm. (when the denier of the thread exceeds 500). A steel needle, 0.4 mm. in diameter and bent through an angle of 120° to form a hook is inserted immediately below the suspension clamp into the yarn and as closely as possible to the centre of the bundle of filaments.

At least $\frac{1}{4}$ of the total number of filaments should be on one side of the hook, however, it is preferred that at least 1/3 of the total filaments should be on one side of the hook, thus leaving 2/3 of the filaments on the other side.

The hook is carefully lowered by hand (so as not to damage the filaments) at a rate of the order of 2 cm. per second. The hook may be lowered without causing damage to the filaments although possibly unravelling some slight entanglements of them, until a point is reached where the filaments become heavily interlaced and further lowering will only result in breakage of the filaments. At this point the distance traversed by the hook through the thread is then read. This gives the "hook drop" distance for the thread. Hook drop distances of more than 50 cm. are recorded as 100 cm., since at this distance the coherency factor of the yarn is $\frac{100}{50}$,

=2. If the coherency factor of the thread is less than 1.5 the entanglement of the filaments is insufficient. Hence as the lower limit of sufficient entanglement of the thread is a coherency factor of 2, hook drop distances of greater than 50 cm. are arbitrarily recorded as 100 cm. Since the needle is inserted rather inaccurately at the upper end of the thread, 0.5 cm. should be subtracted from the hook drop distance initially obtained.

The determination is repeated 10 or more times with additional samples of the same yarn. From these results the average hook drop distance ($\bar{X}$) is calculated.

The coherency factor of the thread is given by $\frac{100}{\bar{X}}$.

If a multi-filament thread is to be capable of being processed without being twisted, it should have a coherency factor of at least 1.5.

EXAMPLE I

A nylon thread having a denier of 70, a twist of 20 turns per metre, and made up of 24 filaments, was treated by the method of the invention with the apparatus described with reference to Figure 3. The distance from the nozzle exit, 5, to the thread, 4, was 1 mm., from the thread to the inlet, 6, 2 mm., and from the chamber outlet, 10, to the thread, 1 mm.

The thread was passed through the thread guides, 3, at a rate of 150 metres per minute, so that the tension in the thread before the first thread guide was 0.1 gm. per denier. The ratio of the rate of supply of the thread to the drawing off rate of the thread was 1. The thread was treated with air at a temperature of 20°C which was supplied to the primary nozzle at a gauge pressure of 4 atmospheres.

The treated thread showed a coherency factor of 12.1.

An identical thread was treated in an analagous manner with the aid of an apparatus described in Canadian Patent No. 554,150 and an apparatus in accordance with Figure 4 of United States Patent No. 2,985,995 respectively. The yarns obtained had coherency factors of 4.5 and 3.6 respectively.

Thus it can be seen that under analagous conditions the apparatus of the present invention resulted in a yarn having a considerably higher coherency factor.

EXAMPLE II

Example 1 was repeated with the following exceptions. Two runs (1 and 2) were carried out in which the tension in the thread was 0.3 and 0.03 gm. per denier respectively and the gauge pressure of the primary gas jet was 10 and 1.5 atmospheres respectively. In a third run (run 3), steam at a temperature of 120°C and having a gauge pressure of 0.5 atmospheres was used instead of air. The tension in the thread was 0.03 gm. per denier, and the ratio of feed rate to drawing off rate of the thread was 0.96.

The test conditions and the results obtained are shown in Table I.

TABLE I

Run	*Thread tension in g/denier*	*Ratio of feed rate to drawing off rate*	*Gauge pressure in atm.*	*Coherency factor*
1	0.3	1.0	air 10	3.1
2	0.03	1.0	air 1.5	2.6
3	0.03	0.96	steam 0.5 120°C	8.7

EXAMPLE III

Example 1 was repeated with the following exceptions. Three runs (4, 5 and 6) were carried out in which the thread tension was 0.0, 0.04 and 0.1 gm. per denier respectively and the ratio of the feed rate to the drawing off rate of the thread was 0.98, 0.99 and 1.0 respectively. A fourth run (7) was carried out, in which, before winding, the thread was wetted with water, a thread tension of 0.1 gm. per denier and a ratio of feed rate to drawing off rate of 1.0 were employed.

A fifth run (run 8) was carried out using a thread tension of 0.1 gm. per denier and a ratio of feed rate to drawing off rate of 1.0, however, in contrast with run number 6, no use was made of a nozzle to guide the secondary gas stream.

The test conditions and results for these runs are set out in Table II.

TABLE II

Run	*Thread tension in g/denier*	*Ratio of feed rate to drawing off rate*		*Coherency factor*
4	0.0	0.98	loops on thread surface	17.8
5	0.04	0.99		15.4
6	0.1	1.0		13.2
7	0.1	1.0	thread wetted after the treatment	27.1
8	0.1	1.0	nozzle 10 not present	5.4

It can be seen from these results, that in runs 4, 5 and 6, a certain tension is required in the thread to prevent the occurrence of loops on the thread surface. Run 7 clearly shows that wetting the thread after treatment by the method of the invention, has a favourable effect on the thread obtained.

Runs 6 and 8 show the desirability of having a nozzle in the outlet of the chamber

in order to direct the secondary gas stream onto the thread.

EXAMPLE IV

In this series of experiments, six different runs were made. Run 9 was carried out using the apparatus shown and described with reference to Figure 4, run 10 was carried out using the apparatus described with reference to Figure 1 and runs 11 to 13 inclusive were carried out in the apparatus described with reference to Figure 3. Run 14 was carried out with an apparatus in which the primary and secondary gas streams came into contact with the thread at an angle which was varied from acute to obtuse.

The other test conditions were identical with those of Example I except that instead of a nylon thread, run 12 was carried out with a polyethylene terephthalate thread (75 denier, 36 filaments, twist 40 turns per metre) and runs 13 and 14 were carried out with a viscose rayon thread (75 denier, 30 filaments, twist 0).

The test conditions and results are set out in Table III.

TABLE III

Run	*Type of Thread*	*Turns/ metre*	*Apparatus*	*Coherency factor*
9	Nylon 70/24	20	Fig. 4	6.7
10	„ „	20	Fig. 1	5.7
11	„ „	20	Fig. 3	11.9
12	Polyethylene terephthalate 75/36	40	Fig. 3	13.6
13	Viscose rayon	0	Fig. 3	12.9
14	„ „	0		lower than 12.9

EXAMPLE V

Two runs, 15 and 16, were carried out using the apparatus described with reference to Figure 3. The test conditions were identical with those set out in Example I except that the distances from the nozzle to the thread, from the thread to chamber inlet, and from chamber outlet to thread, were varied.

The test conditions and results are set out in Table IV.

TABLE IV

Run	*Nylon 70/24*	*Turns/ metre*	*Apparatus*	*Distance nozzle to thread in mm.*	*Distance chamber inlet to thread in mm.*	*Distance chamber outlet to thread in mm.*	*Coherency factor*
15	„	20	Fig. 3	1	5	0.5	3.8
16	„	20	Fig. 3	3	2	2	2.9

WHAT WE CLAIM IS:—

1. A method for treating a moving artificial multi-filament thread having little or no twist with a stream of gas, which method comprises directing at least one primary gas stream having a velocity of at least 200 m/sec. onto a thread running between guides, guiding the gas stream after it has passed the thread into an enclosed space and subsequently directing the gas stream from the enclosed space onto the thread as a single or multiple secondary gas stream at a point or points remote from that at which the primary gas stream comes into contact with the thread, wherein the primary gas stream issues from a primary gas jet at a gauge pressure within the range 0.5 to 10 atmospheres, and wherein the thread passing the gas streams is under a tension of from 0.03 to 0.3 gm. per denier.

2. A method as claimed in claim 1, wherein the primary gas stream is perpendicular to the thread.

3. A method as claimed in claim 2, wherein the secondary gas stream is perpendicular to the thread, but in a direction opposite to that of the primary gas stream.

4. A method as claimed in any one of the preceding claims, wherein the pressure of the gas is increased before the gas leaves the enclosed space.

5. A method as claimed in any one of the preceding claims, wherein residual electrostatic charge is removed from the thread after passing the gas streams prior to winding.

6. A method as claimed in claim 5 wherein the residual electrostatic charge is removed by wetting the thread.

7. A method as claimed in claim 6, wherein the thread is wetted with water containing wetting agent and size.

8. A method as claimed in any one of the preceding claims, wherein the secondary gas stream impinges on a portion of the thread before the point at which the primary gas stream impinges.

9. A method as claimed in any one of claims 1 to 6, wherein the secondary gas stream impinges on a portion of the thread after the point at which the primary gas stream impinges.

10. A method for treating a moving artificial multi-filament thread, with a stream of gas as claimed in claim 1 substantially as described in any one of the specific examples hereinbefore set forth.

11. A method for treating a moving artificial multi-filament thread with a stream of gas substantially as described with reference to the accompanying drawings.

12. An apparatus for carrying out the

method claimed in any one of the preceding claims, which apparatus comprises a nozzle through which the primary gas stream issues, a chamber provided with an opening opposite the exit of the nozzle, and thread guides so that the line passing through the centres of the thread guides will intersect with the centre line of the nozzle exit wherein, the distance between the nozzle exit and the centre line passing through the thread guides is between 1 and 3 mm. and wherein the chamber is provided with at least one outlet for discharging the gas from the chamber, which outlet debouches towards the thread and at a distance from 0.5 to 2.0 mm. from the line passing through the thread guides but at some distance from the point of intersection of the centre line of the thread guides and the centre line of the nozzle exit.

13. An apparatus as claimed in claim 12, wherein the centre line of the nozzle exit is perpendicular to the centre line of the thread guides.

14. An apparatus as claimed in claim 13, wherein the centre line of the chamber outlet is perpendicular to the centre line passing through the thread guides and wherein the direction of the gas stream leaving the nozzle is opposite to that of the gas stream leaving the chamber outlet.

15. An apparatus as claimed in any one of claims 12 to 14, wherein the inlet of the chamber is similar to the nozzle exit, the ratio of the cross-sectional area of the chamber inlet to the crosssectional area of the nozzle exit has a value within the range 1 to 2 and wherein the chamber outlet has a diameter which is less than the inlet of the chamber.

16. An apparatus as claimed in claim 15. wherein the outlet of the chamber is formed by a nozzle.

17. An apparatus for treating a moving artificial multi-filament thread with a stream of gas as claimed in claim 12 and substantially as hereinbefore described.

18. An apparatus for treating a moving artificial multi-filament thread with a stream of gas substantially as described with reference to Figures 1 to 4 of the accompanying drawings.

19. Multi-filament threads whenever treated by the method claimed in any one of claims 1 to 11 or when processed on the apparatus claimed in any one of claims 12 to 18.

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955,128 COMPLETE SPECIFICATION

1 SHEET

This drawing is a reproduction of the Original on a reduced scale.

Fig.1.

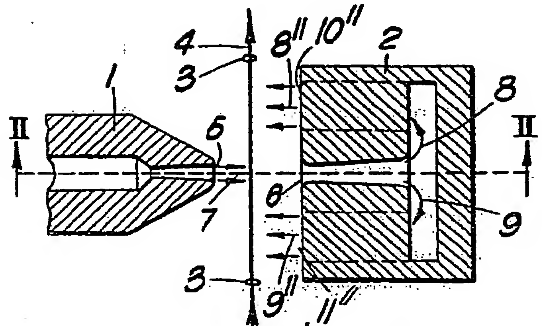

Fig.2.

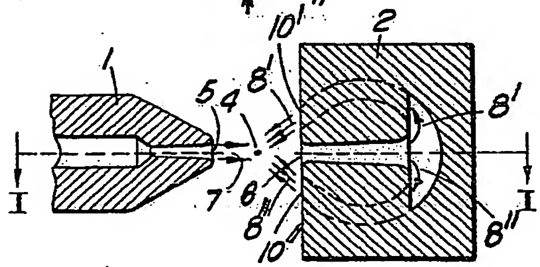

Fig.3.

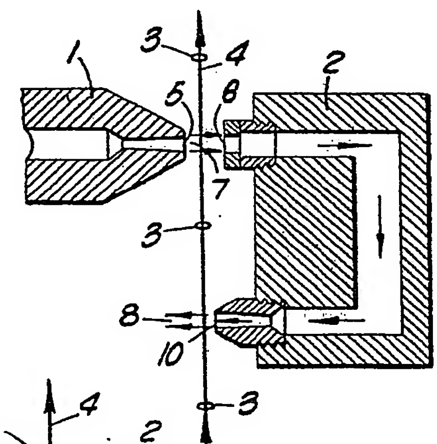

Fig.4.